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TEACHER MANUAL

BUFLO

BUFFALO HERD POPULATION MANAGEMENT

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HUNTINGTON TWO COMPUTER PROJECT

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BUFLO

TEACHER MANUAL

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I. BASIC INFORMATION ABOUT THE UNIT

Subject Area:	Science, Social Studies
Specific Topic:	A Simulation of the Ecology of the North-American Bison (Buffalo)
Grade Level:	7 - 12
Coordinated Computer Program:	*BUFLO*
Computer Language:	BASIC
Special Language Features Used:	TAB, FNA(X)
Abstract:	*BUFLO* is a computer-assisted simulation which allows students to study the historical and biological reasons for the extinction of the buffalo. The *BUFLO* model simulates the natural life cycle of the buffalo and allows the student to manipulate harvesting policies in order to reach certain goals that are outlined in the *STUDENT MANUAL*. The *TEACHER MANUAL* and *RESOURCE MANUAL* provide the necessary background for student guidance and evaluation. Details on model construction will be found in the *RESOURCE MANUAL*.

II. WHY USE *BUFLO*?

The study of ecological systems has become an increasingly relevant and important part of science education at the secondary school level. Studying past events and present consequences with regard to mismanagement of resources, however, does not allow the student any latitude for asking and answering the "what if" questions. Limitations of time, space and resources prohibit actual experimentation, but computer simulation provides an environment in which the "what if" questions can be explored and answered. In addition, *BUFLO* will help the student gain a better understanding of man/machine cooperation in problem solving. His experience with this simulation program will permit exploration of "what if" questions, and will allow him to experiment with policies which might prove disastrous in real life. Simulations such as this actually are useful in formulating decisions on harvesting policies.

III. USING *BUFLO* WITH YOUR CLASS

BUFLO is an ideal exercise for the teacher having access to only one teletype. Assign each group of students a problem from the *STUDENT MANUAL*. The Manual contains plan sheets so students may prepare their investigation before class. Then, after all groups have carried out their unique investigation, have them report their findings to the class as a whole.

Here is one possible format that some teachers have found successful. Have the class play the role of a Congressional Investigation Committee in the year 1830, looking into the possibility of establishing a conservation act for protecting the buffalo. Groups within the Committee have been asked to research a proposal for harvesting buffalo. Inject a note of realism by introducing testimony from the buffalo-hunter interests. These arguments might be presented:

1) Washington is a long way from the Great Plains, and if the Committee passes a law which is too stiff, then the buffalo hunters will probably ignore it (and get away with it too!)

2) Buffalo skins are in demand in the East, and buffalo meat is needed for railroad construction crews in the West. Easterners are politically powerful and the railroad interests form a strong lobby. As elected representatives, the Committee members wouldn't want to lose office, so the chances for conservation reform is slim.

3) Since settlement is starting on the Great Plains, the buffalo cannot be allowed to grow in number because land is needed for farms.

These arguments and the suggestion that the Indians could be controlled if the buffalo were exterminated were actually used with great success during the mass slaughter of the buffalo in the 19th Century.

After the groups within the Committee report, have the Committee as a whole debate and reach a compromise solution. Then, test their solution using *BUFLO*.

Of course, the teacher having more than one teletype has this and many more options open to him. Look through the *STUDENT* and *TEACHER MANUALS* and let your experience and imagination guide you in the selection of an appropriate exercise.

A. Preparatory Activities

- Have your class investigate the life history of the buffalo. Materials in the *STUDENT* and *RESOURCE MANUALS* may serve this purpose.
- Define the term *carrying capacity* as the number of organisms (in this case, buffalo) that the environment is capable of maintaining from year to year.
- Explain to your class the mechanics of initializing *BUFLO* and inputting the harvesting quota. Many teachers have made overhead projections of a sample run for this purpose.
- Assumptions underlying the *BUFLO* model should be explained to the students. A list of these assumptions may be found in the *RESOURCE MANUAL*. These assumptions can be compared with the information learned about the biology of the buffalo. (See *RESOURCE MANUAL*, pp. 4-5.)

B. Evaluation and Follow-Up

- Encourage the spirit of inquiry and exploration by indicating there are no *right* or *wrong* answers to the student investigations. In a real sense, there are different solutions for each set of criteria.
- Discuss the alternative strategies for maintaining the buffalo herd. Have the students compare the advantages and disadvantages of each.
- Discuss why measures were not taken to protect the buffalo before it was almost too late.
- Ask the students if they can name any animals or plants that are now being threatened with extinction (timber wolf, bald eagle, mountain lion, etc.). Ask them to investigate what is being done to help protect these species. This approach may help them understand why very little was done to help protect the buffalo at the time.

IV. DESCRIPTION OF THE *BUFLO* PROGRAM

The first question *BUFLO* asks is:

```
HAVE YOU USED BUFLO BEFORE (1=YES, 0=NO)?
```

By having the instructions dittoed ahead of time, or, by having the students refer to the COMPUTER LABORATORY GUIDE in the *STUDENT MANUAL* much time can be saved.

Next the program asks:

```
THERE ARE TWO POLICIES OF HERD MANAGEMENT AVAILABLE.
TOTAL FREEDOM OF HERD CONTROL (1)
OR AUTOMATIC SAFEGUARDS FOR HERD POPULATION (2)
WHICH POLICY DO YOU PREFER ?
```

If the student chooses (1), he will be allowed to continue to harvest under any circumstances. Choice (2) halts harvesting anytime the herd is placed in danger of extinction. But Choice (2) does not offer complete protection. If the harvesting is not carefully planned, the herd can still be destroyed.

Then the program will ask:

```
YEARS FOR OBSERVE, CHANGE POLICY, REPORT ?
```

This is the most difficult question in the program and you may have to help your students the first time they encounter it. A proper response consists of three numbers separated by commas. The first number represents the total number of years the herd is to be studied. For example, if the student wants to study the herd for ten years, the first number should be typed as "10". The second number asks how often policy changes should be allowed. The number "1" means every year, "2" means every second year, and so on. So if the student wants to have the same policy over the entire period (10 years), he should ask for policy change every 10th year. This is done by typing "10" for the second number. The third number asks how often the student wants population reports. If the student wants population reports every year, he would respond by typing "1" for the third number. So the student's response would look like:

```
10,10,1
```

(The *STUDENT MANUAL* is very specific on the proper response, so if your students carry out manual investigations, they should have little trouble.)

Next, the computer will type:

```
CARRYING CAPACITY?
```

Again, the *STUDENT MANUAL* guides the student in the selection of a proper number, but 40 million (written as 40E6 or 40000000) represents a realistic number for the middle 19th Century.

Then:

```
STARTING YEAR?
```

Any year number may be used. If the student types 1850, it means that he is starting his simulation in the year 1850.

```
WILL YOU INITIALIZE NUMBER OF BUFFALO BY
BREAKDOWN (1) OR TOTAL HERD (2) ?
```

Have the students select Choice (2). Then by typing in the total herd population, the computer will break the herd into Adult Males, symbolized as AM, Adult Females (AF), Yearling Males (YM), Yearling Females (YF), Calf Males (CM), and Calf Females (CF).

BUFLO will then print a heading similar to the one below:

```
                                          PERCENTAGE OF ORIGINAL POPULATION
SYM/GROUP    POP         QUOTA         0            100           200            300
---------    ---         -----         I------------I-------------I-------------I
SPRING OF  YEAR  1860                                CYA
HERD SIZE + 20000000
A    AM    7560000         ?
A    AF    6760000         ?
Y    YM    1240000         ?
Y    YF    920000          ?
C    CM    1820000         ?
C    CF    1700000         ?
```

On the right, *BUFLO* prints a normalized graph. The total number of adults is plotted as "A", the yearlings as "Y" and the calves as "C". If two numbers have the same normalized value, the letters will be printed next to each other without a space between them.

On the left, *BUFLO* gives the Year, Total Herd Size, and a Population breakdown. Shown in the above sample is the breakdown of the Adult Males (AM). First the graph symbol A is printed, then the letters AM, then the population of the adult males, and finally a question mark.

The question mark is asking the student to set a harvesting quota. It essentially says, HOW MANY OF THE ADULT MALES SHOULD BE HARVESTED EACH YEAR? This question mark will appear for each population group in any year in which policy is to be changed. In this example the student might want to harvest ten thousand adult males. After the question mark he would type 10000 (remember no commas!).

At the end of the period of study, the computer prints:

TOTAL HARVEST FOR (T) YEARS IS (H) BUFFALO.

Consult annotated sample runs in the *RESOURCE MANUAL* for more information.

V. TEACHER KEY TO *STUDENT MANUAL* INVESTIGATIONS

The *STUDENT MANUAL* is divided into two sections. *PART I* investigates historical aspects of the buffalo slaughter in the 19th Century. Students investigate the question "Could large numbers of buffalo have been harvested without driving this species to the edge of extinction?"

A. DETERMINE THE EFFECTS OF HARVESTING ADULT MALES OVER A FIVE-YEAR PERIOD.

Students will be surprised to find out that large numbers of adult males can be harvested with very little lowering of the population. Buffalo, being polygamous, require a relatively small number of males to produce the next generation.

In the following sample run, the student has harvested 1,300,000 male buffalo per year over a 5-year period. This produces a total harvest of 6.5 million.

```
             BUFFALO HERD MANAGEMENT

HAVE YOU USED BUFLO BEFORE (1=YES, 0=NO) ?1

WHICH POLICY DO YOU PREFER ?1

YEARS FOR OBSERVE, CHANGE POLICY, REPORT ?5,5,1

CARRYING CAPACITY ?40E6

STARTING YEAR= ?1830

WILL YOU INITIALIZE NUMBER OF BUFFALO BY
BREAKDOWN (1) OR TOTAL HERD (2) ?2
TOTAL BUFFALO IN HERD ?20E6
```

```
                   HARVEST        PERCENTAGE OF ORIGINAL POPULATION
SYM/GROUP   POP     QUOTA      0           100          200          300
---------   ---     -----      I------------I------------I------------I
SPRING OF YEAR  1830                       CYA
HERD SIZE= 20000000
A  AM  7560000      ?1300000
A  AF  6760000       ?0
Y  YM  1240000       ?0
Y  YF  920000        ?0
C  CM  1820000       ?0
C  CF  1700000       ?0

SPRING OF YEAR  1831                      AY   C
HERD SIZE= 20191107
A  AM  6563999
A  AF  6773999
Y  YM  1092000
Y  YF  1020000
C  CM  2465377
C  CF  2275732

SPRING OF YEAR  1832                     A     YC
HERD SIZE= 19993822
A  AM  5556598
A  AF  6861598
Y  YM  1479226
Y  YF  1365439
C  CM  2460100
C  CF  2270861

SPRING OF YEAR  1833                     A     YC
HERD SIZE= 19760297
A  AM  4940356
A  AF  7199516
Y  YM  1476060
Y  YF  1362517
C  CM  2486561
C  CF  2295287

SPRING OF YEAR  1834                    A      YC
HERD SIZE= 19788503
A  AM  4383364
A  AF  7501451
Y  YM  1491937
Y  YF  1377172
C  CM  2617931
C  CF  2416598

SPRING OF YEAR  1835                    A       YC
HERD SIZE= 19941374
A  AM  3893979
A  AF  7784183
Y  YM  1570789
Y  YF  1449959
C  CM  2726081
C  CF  2516383

 TOTAL HARVEST IN 5 YEARS IS 6500000 BUFFALO.
```

B. DETERMINE THE EFFECTS OF HARVESTING ADULT MALES OVER A 25-YEAR PERIOD (LONG TERM).

The same effect as noted in Section A will be seen in this investigation. In fact, even larger yearly harvests are possible, if the student is willing to place the herd in the precarious position of very few males and many females.

The following run has been condensed to fit a single page.

```
              BUFFALO HERD MANAGEMENT

HAVE YOU USED BUFLO BEFORE (1=YES, 0=NO) ?1

WHICH POLICY DO YOU PREFER ?1

YEARS FOR OBSERVE, CHANGE POLICY, REPORT ?25,25,5

CARRYING CAPACITY ?40E6

STARTING YEAR= ?1830

WILL YOU INITIALIZE NUMBER OF BUFFALO BY
BREAKDOWN (1) OR TOTAL HERD (2) ?2
TOTAL BUFFALO IN HERD ?20E6

                 HARVEST       PERCENTAGE OF ORIGINAL POPULATION
SYM/GROUP  POP    QUOTA    0          100         200         300
---------  ---    -----    I-----------I-----------I-----------I
SPRING OF YEAR  1830                   CYA
HERD SIZE= 20000000
A  AM  7560000      ?1469000
A  AF  6760000      ?0
Y  YM  1240000      ?0
Y  YF  920000       ?0
C  CM  1820000      ?
;;TTY24: - HI!
0
C  CF  1700000      ?0

SPRING OF YEAR  1835                A      YC
HERD SIZE= 19420033
A  AM  3284711
A  AF  7796734
       1583335
        61540

SPRING OF YEAR  1855                      A          YC
HERD SIZE= 31756001
A  AM  3739132
A  AF  14751059
Y  YM  2570604
Y  YF  2372866
C  CM  4327617
C  CF  3994723


 TOTAL HARVEST IN 25 YEARS IS 36725000 BUFFALO.
```

C. DETERMINE EFFECT OF A HARVESTING POLICY IN WHICH ONLY ADULT FEMALES ARE HARVESTED.

The students will discover that females are far more important to population maintenance than males. Below are condensed RUNS of both 5-year and 25-year investigations:

5-YEAR STUDY

```
           BUFFALO HERD MANAGEMENT

HAVE YOU USED BUFLO BEFORE (1=YES, 0=NO) ?1

WHICH POLICY DO YOU PREFER ?1

YEARS FOR OBSERVE, CHANGE POLICY, REPORT ?5,5,1

CARRYING CAPACITY ?40E6

STARTING YEAR= ?1830

WILL YOU INITIALIZE NUMBER OF BUFFALO BY
BREAKDOWN (1) OR TOTAL HERD (2) ?2
TOTAL BUFFALO IN HERD ?20E6

                       HARVEST        PERCENTAGE OF ORIGINAL POPULATION
SYM/GROUP   POP        QUOTA      0            100         200         300
---------   ---        -----      I------------I------------I------------I
SPRING OF YEAR  1830                           CYA
HERD SIZE= 20000000
A   AM   7560000         ?0
A   AF   6760000         ?400000
Y   YM   1240000         ?0
Y   YF   920000          ?0
C   CM   1820000         ?0
C   CF   1700000         ?0

SPRING OF YEAR  1831
HER       20537643
            9

SPRING OF YEAR  1835                          AYC
HERD SIZE= 19833950
A   AM   8088872
A   AF   5759061
Y   YM   1131194
Y   YF   1044179
C   CM   1981535
C   CF   1829109

 TOTAL HARVEST IN 5 YEARS IS 2000000 BUFFALO.
```

25-YEAR STUDY

```
                    BUFFALO HERD MANAGEMENT

HAVE YOU USED BUFLO BEFORE (1=YES, 0=NO) ?1

WHICH POLICY DO YOU PREFER ?1

YEARS FOR OBSERVE, CHANGE POLICY, REPORT ?25,25,5

CARRYING CAPACITY ?40E6

STARTING YEAR= ?1830

WILL YOU INITIALIZE NUMBER OF BUFFALO BY
BREAKDOWN (1) OR TOTAL HERD (2) ?2
TOTAL BUFFALO IN HERD ?20E6

                        HARVEST         PERCENTAGE OF ORIGINAL POPULATION
SYM/GROUP   POP          QUOTA        0             100           200          300
---------   ---          -----        I-------------I-------------I------------I
SPRING OF YEAR  1830                                CYA
HERD SIZE= 20000000
A   AM   7560000          ?0
A   AF   6760000         ?280000
Y   YM   1240000          ?0
Y   YF   920000           ?0
C   CM   1820000          ?0
C   CF   1700000          ?0

SPRING OF YEAR  1835                                AYC
HERD SIZE= 21096017
A   AM   8238400
A   AF   6339473
Y   YM   1237640
Y   YF   1142437
C   CM   2151795
C   CF   1986272

SPRING OF YEAR  1840                                AYC
HERD SIZE= 21138495
A   AM   8622499
A   AF   6180175
Y   YM   1204322
Y   YF   1111682
C   CM   2090305
C   CF   1929512

              OF YEAR
                   208
SPRING OF YEAR  1855                                YAC
HERD SIZE= 19868621
A   AM   8565088
A   AF   5538787
Y   YM   1093142
Y   YF   1009054
C   CM   1904526
C   CF   1758024


 TOTAL HARVEST IN 25 YEARS IS 7000000 BUFFALO.
```

SUMMARY -- You might want to do something similar with data from your class. The information on the chart below comes from the sample runs on the previous pages.

COMPARISON OF MALE AND FEMALE HARVESTING POLICIES AIMED AT A CONSTANT POPULATION

5-YEAR PERIOD	QUOTA (kill/year)	HARVEST
Males only	1.3 million	6.5 million
Females only	400 thousand	2 million

25-YEAR PERIOD	QUOTA (kill/year)	HARVEST
Males only	1.469 million	36.725 million
Females only	280 thousand	7 million

NOTE THAT MUCH LARGER HARVESTS WERE POSSIBLE WHEN TAKING MALES.

D. DETERMINE THE EFFECTS OF HARVESTING BOTH ADULT MALES AND ADULT FEMALES OVER 5-YEAR AND 25-YEAR PERIODS.

This investigation is much more open. You may wish to restrict your students by instructing them to:

1) maintain the same harvesting policy over the entire period
2) maintain a certain harvesting ratio (such as 50-50)
3) receive reports at certain intervals

No sample runs are shown as there is no unique method of solution.

PART II of the *STUDENT MANUAL* is set in the framework of game management in the United States today. Students are given a buffalo herd and asked to design several strategies to reach a certain goal.

To ensure student success, encourage them to experiment with:

a) harvesting different ages
b) harvesting only in certain years
c) harvesting the sexes differently

To allow total freedom in investigation, students should have the option of changing policy every year. This can be done by responding to

```
YEARS FOR OBSERVE, CHANGE POLICY, REPORT ?
```

with a "1" in the second and third positions. So, if the student wants to investigate a 20-year period, he would type: 20,1,1

VI. WHAT CAN STUDENTS LEARN BY USING THIS UNIT?

After the student has completed a science unit centered around *BUFLO*, he should be able to:

1) Describe the effects of various harvesting policies.

2) Describe one harvesting strategy which would effect maintenance of the present buffalo population of 26,000.

3) Understand the reasons for limiting the number of doe which deer hunters are permitted to take in any single season.

4) Explain the limitations to which the model, and any predictions made with it, are subject.

5) Appreciate the value of careful management of our natural resources (e.g., whales, seals, forests, etc.).